METHOD OF MAKING A TWO-PIECE SUPER-PLASTIC FORMED LIGHTWEIGHT ALUMINUM DOOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the manufacture of vehicle doors.

2. Background Art

Conventional vehicle doors are generally stamped from steel blanks in a press forming line including a first drawing step followed by trimming, flanging, and piercing operations. Normally, an inner door panel and an outer door panel are formed in separate stamping operations. The inner and outer door panels are then assembled together with reinforcement bars, brackets and other components. It is not unusual for a conventional vehicle door to have as many as 20 pieces in the completed assembly.

Doors made by a stamping process are limited by manufacturing constraints to relatively shallow contours and are limited to the extent that feature lines may be formed in the door panels. For example, stamped doors cannot be made with feature lines that originate in a flat surface at the middle of a panel.

Conventional vehicle doors made with a large number of pieces tend to suffer from a lack of dimensional control due to the stack up of tolerances permitted for each part. Poor dimensional control adversely impacts vehicle craftsmanship and quality assessment target achievement. Parts are made within a certain degree of dimensional tolerance but when additional parts are assembled together, the tolerances may accumulate making it difficult to control the final dimensional tolerances of the finished door assembly.

It has been proposed to manufacture vehicle doors from aluminum to save weight. Aluminum doors made in a conventional stamping line must generally be manufactured from aluminum sheet that is less than 0.9 mm in thickness. If thicker aluminum sheet is used, excessive splitting and cracking may occur especially in tight radius bends. Door inner and outer panels made with 0.9 mm aluminum are too thin generally to accept mounting hardware without additional reinforcement.

Super-plastic forming (SPF) technology has been used in the manufacture of vehicles including the manufacture of decklids and hoods. In one such door, aluminum having a thickness of 0.9 mm is super-plastic formed and a cast hinge plate and cast striker plate are secured to reinforce the door mounting hardware.

It has also been proposed to use thermally cured adhesives to aid in securing panels of vehicle parts together. Thermally cured adhesives may shift when heated in an oven. Any shift in the position of the door inner relative to the door outer can result in unacceptable dimensional variation.

There is a need for a lightweight vehicle door structure that does not require added reinforcements other than those integrally formed in the inner door panel. Adding reinforcements increases the weight of the overall door assembly.

Further, vehicle fit and finish requirements for world class vehicle manufacturing demand dimensional control of the inner and outer door panels to within 1 mm and of the assembled door inner and outer to be less than 1.25 mm. There is also a need for a manufacturing process that permits wider latitude in design shape and feature line capability.

It would be desirable to reduce the total part count by eliminating reinforcements, such as door hinge and latch reinforcements, and at the same time there is a need for greater dimensional control. Further, there is a need for a vehicle door that does not distort or shift in position when exposed to heat during electro-coat processes and in paint ovens.

These and other problems and needs are addressed by applicants' invention as summarized below.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, a method of making a vehicle door is provided that comprises super-plastic forming inner and outer door panels that are subsequently trimmed and assembled together. A peripheral flange is formed on the outer door panel and a two-part adhesive is applied to the inner door panel in areas adjacent to the peripheral flange of the outer door panel. The peripheral flange is hemmed over the inner door panel to secure the inner and outer door panels together. The two-part adhesive is cured to secure the inner and outer door panels together.

According to other aspects of the invention, the two-part adhesive may be a room temperature curable epoxy adhesive and the inner and outer door panels may be formed from aluminum alloy such as 5083 aluminum alloy that is available from Sky Aluminum Company. The door may be subsequently heated in an oven after the curing step is completed.

Other aspects of the invention relate to hinge attachment and striker hardware attachment areas on the door panels. During the super-plastic forming step, the hinge attachment area and striker hardware attachment area are not substantially thinned or stretched so as to reduce their strength. No reinforcement members are required to be added to the door assembly because these areas maintain their strength and thickness.

According to another aspect of the present invention, a vehicle door assembly is provided that comprises an aluminum super-plastic formed inner door panel having an outwardly extending perimeter flange. The door also includes an aluminum super-plastic formed outer panel having an outer perimeter flange that encompasses the inner perimeter flange of the inner door panel in a reversely turned hem configuration. The inner door panel flange and outer perimeter flange of the outer door panel are bonded together with an adhesive to form a monolithic door structure without additional reinforcements being required for structural integrity.

According to other aspects of the invention as they relate to a vehicle door assembly, the door assembly may have a hinge attachment area and a striker hardware attachment area that are not substantially stretched or thinned during the super-plastic forming process. The inner and outer door panels may be formed from aluminum sheet metal blanks that are 1.5 millimeters thick. The inner and outer door panels are joined by a two-part room temperature curable epoxy adhesive. The inner and outer door panels are also held together by a roll formed hem flange in addition to the adhesive. Other components may be attached to the door assembly but no reinforcements or brackets are required to enforce the structural integrity of the door assembly.

These and other aspects of the invention will be better understood in view of the attached drawings and subsequent detailed description of the illustrated embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a flow chart illustrating the steps of a process for forming a door assembly;